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IDENTIFICATION OF STUDENT'S METACOGNITIVE CHARACTERISTIC AND ITS LEVEL PATTERN IN PROBLEM SOLVING OF CHEMICAL BONDING MATTER IN SMAN 1 KRIAN

Siti Masrifah and Bambang Sugiarto
Chemistry Department, Mathematical and Natural Science Faculty
State University of Surabaya
Hp 08563285344, e-mail: myrifanatic@gmail.com

Abstrak

Tujuan dari penelitian ini adalah untuk mendeskripsikan pola karakteristik dan level metakognitif siswa dalam memecahkan masalah pada materi ikatan kimia di SMAN 1 Krian. Jenis penelitian ini adalah penelitian kualitatif. Subjek penelitian adalah 9 siswa kelas X MIA 7 SMA Negeri 1 Krian yang terdiri dari tiga kelompok yaitu kelompok tinggi, sedang, dan rendah serta instrumen utamanya adalah peneliti. Data yang dikumpulkan antara lain jawaban tes tulis dan wawancara yang didukung dengan *camera recorder* serta catatan lapangan dan dicek keabsahannya melalui triangulasi metode. Metode yang digunakan adalah observasi hasil tes tulis dan wawancara. Hasil penelitian menunjukkan bahwa siswa kelompok tinggi memiliki karakteristik metakognitif pada aktivitas perencanaan yaitu berpikir/ membaca/ menulis apa yang diketahui (P-1), menetapkan strategi penyelesaian masalah (P-3), dan merencanakan suatu representasi persamaan atau gambar untuk mendukung pemahaman (P-5); aktivitas pemantauan yaitu menggunakan aturan persamaan (M-2), memantau sesuatu yang dianggap kesalahan (M-3), memantau dengan cermat dalam penyelesaian masalah (M-4), dan memantau dengan berargumentasi (M-5); aktivitas refleksi yaitu merefleksi pada konsep/ tujuan yang telah dicapai (R-1) dan merefleksi penerapan/ penggunaan strategi yang lebih efisien (R-2) serta menempati level *reflective use*. Kelompok sedang memiliki karakteristik metakognitif yaitu (P-1), (P-3), (P-5), (M-3), dan (M-4) serta menempati level *strategic use.* Kelompok rendah memiliki karakteristik metakognitif yaitu (P-1), (P-3), (P-5), dan (M-4) serta menempati level *aware use*.

Kata kunci: Karakteristik dan Level Metakognitif, Memecahkan Masalah, Ikatan Kimia.

Abstract

The purpose of this research was to describe the student's metacognitive characteristic and its level pattern in problem solving of chemical bonding matter in SMAN 1 Krian. The type of this research is qualitative research. The subjects were 9 students of class X MIA 7 SMAN 1 Krian which consists of three groups: high, moderate, and low group and the main instrument was the researcher. Data collected include written test answer and interview that are supported by camera recorder and field notes and subsequently checked for validity through triangulation method. Observation of written test results and interview method was used in this research. The result of research shows that students in high group have metacognitive characteristics in planning activities that are thinking/ reading/ writing what is known (P-1), defining problem-solving strategies (P-3), and planning an equation or picture representation to support understanding (P-5); monitoring activities that are using the rule (M-2), monitoring what is considered error (M-3), monitoring carefully in problem solving (M-4), and monitoring by arguing (M-5); reflection activities that are reflecting the concept/ objectives have been achieved (R-1) and reflecting the implementation/ use of more efficient strategies (R-2) and placed in reflective use level. Students in moderate group have metacognitive characteristics (P-1), (P-3), (P-5), (M-3), and (M-4) and placed in strategic use level. Students in low group have metacognitive characteristics (P-1), (P-3), (P-5), and (M-4) and placed in aware use level.

Keywords: *Metacognitive Characteristic and Level, Problem Solving, Chemical Bonding*

INTRODUCTION

Based on the regulation of Education and Culture Ministry of Republic of Indonesia Number 69 year 2013 on the Primary Framework and Curriculum Structure of Senior High School/Madrasah Aliyah, one of the major challenges faced as a factor for curriculum development in 2013 is how to strive for productive age human resources are abundant can be transformed into human resources who have the competence and skills through education so as not to be a burden [1]. Education can be obtained by citizens through educational institutions, including schools. One of the sciences learned in school is a chemistry that is included in the natural sciences. An abstract concept in chemistry is chemical bonding. Chemical bonding is an abstract concept that can not be applied in everyday life directly and many students have difficulties in understanding this concept [2].

According Pulmones (2007), abstract nature of chemistry make the concepts and principles should be studied meaningfully so that students must be given the opportunity to utilize the knowledge they have previously to construct new knowledge [3]. Early on, students must be trained and socialized to think independently. When faced with a problem, student will think and act to find an answer or solution. It can train students to use the knowledge and skills they have in solving the problem so it can improve the ability to think. Knowledge of one's own thinking ability is the result of metacognition process.

John Flavell (1979), defines metacognition as students' knowledge or awareness, consideration, and control of their processes and cognitive strategies. Flavell also divide metacognitive skills into three parts, namely planning skills, monitoring skills, and evaluation skills [4]. These activities can help in solving the problems faced. The process is suitable with the problem solving steps described by Polya (1973) that are understand the problem, plan a solution, implement the solution plan, and check back [5].

Each student has a different awareness and capability in facing the problems because they have different uses of strategy in the problem-solving process. Swartz and Perkins divide the awareness level of students in thinking when solving a problem into four, namely: (1) Tacit use is the type of thinking in which the decision-making student does not think about the decision. (2) Aware use is the type of thinking in which the student has an awareness of what and why do these thoughts. (3) Strategic use is the type of thinking in which student organize consciously thinking process by using specific strategies that can improve the precision of thinking. (4) Reflective use is the type of thinking in which the student reflects on his thinking process before and after or even during the process by considering the continuation and improvement of the thinking results [6].

Based on that reason it is needed the research about student's metacognitive characteristic and its level pattern in problem solving of chemical bonding matter. The purpose of this research is to describe the student's metacognitive characteristic and its level pattern in problem solving of chemical bonding matter in SMAN 1 Krian.

METHOD

The type of this research is qualitative research. The subjects were students of class X MIA 7 SMAN 1 Krian. Selection of subjects performed with purposive sampling. Grouping the subjects into high, moderate and low group based on academic ability by the score of daily test previous matter. Subjects do daily test of chemical bonding then conducted interview to reveal the thinking process when doing the test and obtained 9 research subjects. The data used for the analysis is the result of daily tests and

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interviews then identified based on the characteristics of metacognitive indicator according Sugiarto (2012) [7] and metacognitive level refers to the theory of Swartz and Perkins [6]. To get the validity of the data used triangulation method by comparing the observed data on the writing test with interview result [8].

RESULT AND DISCUSSION

The following are the problem solving result of chemical bonding matter which is analyzed to know metacognitive characteristic that are planning, monitoring, and reflection.

High Group

Subject in high group is represented by the subject FKS. Here is the result of problem solving in chemical bonding matter by FKS.

1) Problem 2c "Draw the Lewis symbol of HCN compound".

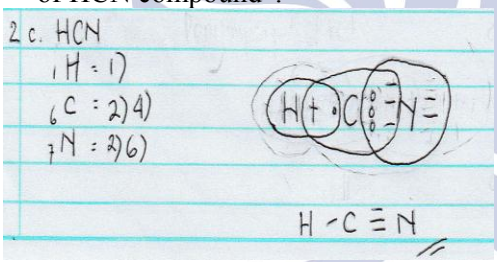

Figure 1 Sample of FKS answer on problem 2c

Analysis of FKS's metacognitive characteristic on problem 2c as follows.

a. Planning

Subject did planning activities by writing what is known on the problem (P-1) that are HCN compound and atomic number of H, C and N. Subject also define problem-solving strategies for drawing Lewis structure (P-3) which is seeking to valence electron by writing the configuration electron of H, C, and N. Interview result also showed that the subject did the activities appropriate indicator (P-1) and (P-3).

b. Monitoring

In the written answer there is erasure on Lewis electron dot figure as an activity of monitoring something that is considered an error to the figure (M-3). Subject also closely monitoring in drawing Lewis structure (M-4) by encircling element and its valence electron to indicate that the element has reached stability. Interview result also showed that the subject did the activities appropriate indicator (M-3) and (M-4).

c. Reflection

Written answer indicates that the subject did activity of reflecting on whether the objectives have been achieved and believe the answer can be seen from the bottom line marks on the answer as an affirmation (R-1). Interview result also showed that the subject did the activities appropriate indicator (R-1).

2) Problem 8a "Predict the ionic compound formula resulted from Mg with Br_2".

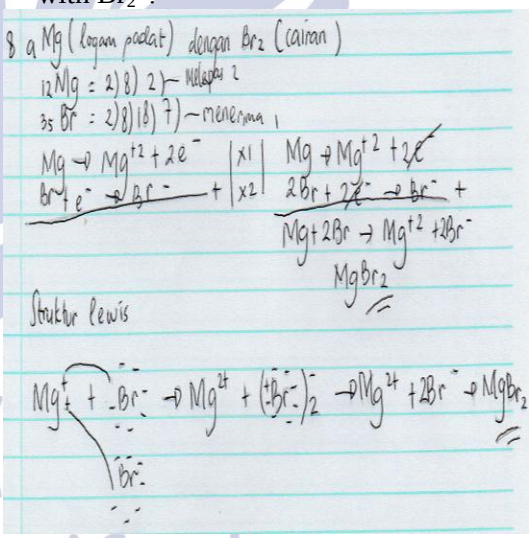

Figure 2 Sample of FKS answer on problem 8a

Analysis of FKS's metacognitive characteristic on problem 8a as follows.

a. Planning

In written answer, subject did planning activities by writing what is known on the problem (P-1) that is Mg with Br_2 and also atomic number of Mg and Br. Subject also define problem-solving strategies to predict ionic compound formula (P-3) which is seeking to valence electron by writing the

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configuration electron of Mg and Br. Additionally, subject also planning a representation in the form of equations to show the release and acceptance of electrons (P-5) by writing the equation of Mg and Br. Interview result also showed that the subject did the activities appropriate indicator (P-1), (P-3), and (P-5).

b. Monitoring

In the answer of daily test, subject did activity of monitoring by arguing (M-5) by adding the words "melepas 2" after the valence electrons Mg and "menerima 1" after Br valence electrons to provide information that Mg release two electrons and Br accept one electron. Subject also using the rule (M-2) by writing an equation to show that Mg release electron and Br receive electron. Beside that, subject carefully monitoring when writing equations to predict the ionic compound formula (M-4) can be seen from the scratch on the electrons in the equation of Mg and Br. Interview result also showed that the subject did the activities appropriate indicator (M-2), (M-4), and (M-5).

c. Reflection

Answer of daily test shows the subject did activity of reflecting on whether the objectives have been achieved and believe the answer can be seen from the bottom line marks on the answer ($MgBr_2$) as an affirmation (R-1). The subjects also reflecting the use of more efficient strategies (R-2) by writing another way that illustrates the release and acceptance of electrons with the Lewis electron dot. Interview result also showed that the subject did the activities appropriate indicator (R-1), and (R-2).

Based on the students awareness level in thinking when solving a problem by Swartz and Perkins, metacognitive level of high group is reflective use because the subject raises metacognitive activities such as planning, monitoring, and reflection after obtaining an answer in problem solving as well as recognize and correct errors in problem solving strategies.

Moderate Group

Subject in moderate group is represented by the subject MZH. Here is the result of problem solving in chemical bonding matter by MZH.

1) Problem 2c "Draw the Lewis symbol of HCN compound"

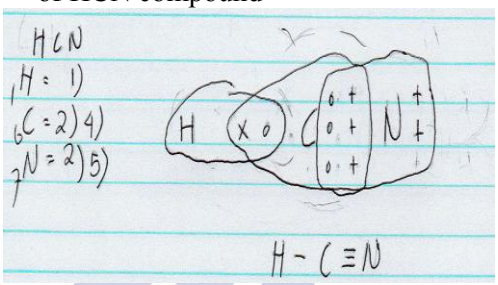

Figure 3 Sample of MZH answer on problem 2c

Analysis of MZH's metacognitive characteristic on problem 2c as follows.

a. Planning

Subject did planning activity by writing what is known on the problem (P-1) that are HCN compound and atomic number of H, C and N. Subject also define problem-solving strategies for drawing Lewis structure (P-3) which is seeking to valence electron by writing the configuration electron of H, C, and N. Interview result also showed that the subject did the activities appropriate indicator (P-1) and (P-3).

b. Monitoring

In the written answer there is erasure on Lewis electron dot figure as an activity of monitoring something that is considered an error to the figure (M-3). Subject also closely monitoring in drawing Lewis structure (M-4) by encircling element and its valence electron to indicate that the element has reached stability. Interview result also showed that the subject did the activities appropriate indicator (M-3) and (M-4).

In solving the problem 2c, subject does not do reflection.

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2) Problem 8a "Predict the ionic compound formula resulting from Mg with Br_2".

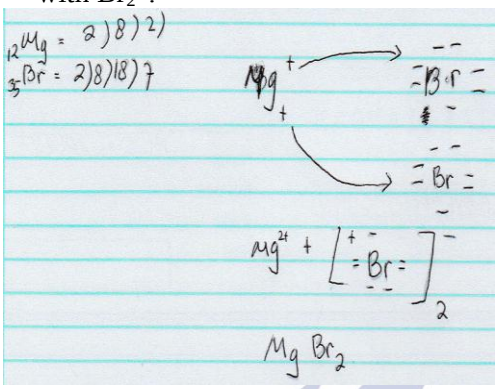

Figure 4 Sample of MZH answer on problem 8a

Analysis of MZH's metacognitive characteristic on problem 8a as follows.

a. Planning

In written answer, subject did planning activity by writing what is known on the problem (P-1) that is Mg with Br_2 and also atomic number of Mg and Br. Subject also define problem-solving strategies to predict ionic compound formula (P-3) which is seeking to valence electron by writing the configuration electron of Mg and Br. Additionally, subject also planning a representation in the form of figure to show the release and acceptance of electrons (P-5) by drawing the Lewis electron dot of Mg and Br. Interview result also showed that the subject did the activities appropriate indicator (P-1), (P-3), and (P-5).

b. Monitoring

In the answer of daily test, the subject did monitoring activity by monitoring closely when drawing Lewis electron dot (M-4), by providing arrow on the Mg valence electron figure that leads to Br valence electron figure to indicate the release of electrons. Subject also monitoring something that is considered to be an error on Lewis electron dot electron figure (M-3) look for scratch in the figure Lewis electron dot of Br. Interview result also showed that the subject did the activities appropriate indicator (M-3) and (M-4).

In solving the problem 8a, subject does not do reflection.

Based on the students awareness level in thinking when solving a problem by Swartz and Perkins, metacognitive level of moderate group is strategic use because subject raises metacognitive activities such as planning and monitoring, as well as aware and is able to select a strategy to solve the problem.

Low Group

Subject in low group is represented by the subject AMH. Here is the result of problem solving in chemical bonding matter by AMH.

1) Problem 2c "Draw the Lewis symbol of HCN compound".

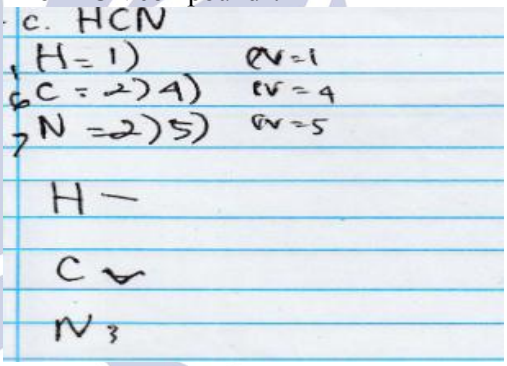

Figure 5 Sample of AMH answer on problem 2c

Analysis of AMH's metacognitive characteristic on problem 2c as follows.

a. Planning

Based on written answer, Subject did planning activity by writing what is known on the problem (P-1) that are HCN compound and atomic number of H, C and N. Subject also define problem-solving strategies for drawing Lewis structure (P-3) which is seeking to valence electron by writing the configuration electron of H, C, and N and adding "ev 1" in valence electron H, "ev 4" in valence electron C, and "ev 5" in valence electron N as information. Interview result also showed that the

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subject did the activities appropriate indicator (P-1) and (P-3).

In solving the problem 2c, subject does not do monitoring and reflection.

2) Problem 8a "Predict the ionic compound formula resulted from Mg with Br_2".

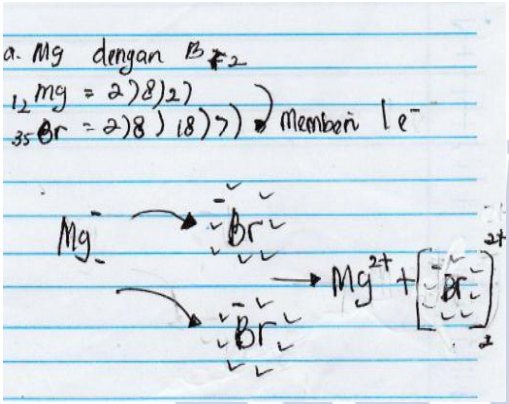

Figure 6 Sample of AMH answer on problem 8a

Analysis of AMH's metacognitive characteristic on problem 8a as follows.

a. Planning

In written answer, subject did planning activity by writing what is known on the problem (P-1) that is Mg with Br_2 and also atomic number of Mg and Br. Subject also define problem-solving strategies to predict ionic compound formula (P-3) which is seeking to valence electron by writing the configuration electron of Mg and Br. Additionally, subject also planning a representation in the form of figure to show the release and acceptance of electrons (P-5) by drawing the Lewis electron dot of Mg and Br. Interview result also showed that the subject did the activities appropriate indicator (P-1), (P-3), and (P-5).

b. Monitoring

In the answer of daily test, the subject did monitoring activity by monitoring closely when drawing Lewis electron dot (M-4), by providing arrows on the Mg valence electron figure that leads to Br valence electron figure to indicate the release of electrons. Subject also monitoring something that is considered to be an error on Lewis electron dot figure (M-3) because there is tipe-x in Br Lewis dot electron figure and charge. Interview result also showed that the subject did the activities appropriate indicator (M-4) but for indicator (M-3) there is no match between the result of daily test and interview so that the (M-3) is not valid.

In solving the problem 8a, subject does not do reflection.

Based on the students awareness level in thinking when solving a problem by Swartz and Perkins, metacognitive level of low group is aware use because subject raises metacognitive activities such as planning and monitoring, as well as realize the use of a step in problem solving by providing an explanation of why choose to perform the steps.

The discussion of some findings or patterns on high, moderate and low group as follows.

1. Metacognitive Characteristic of High Group

Problem solving that is performed by the subject begins with thinking/ reading/ writing what is known and unknown (P-1) by writing a known compound and its atomic number. It shows that the subject could identify important information to solve problem. The things that exist in problem solving, such as what is not known, what data is available, what its terms, and so on are included in the stage of understanding the problems [5].

Further subject define problem solving strategies (P-3) by writing the electron configuration and planning a representation in the form of equation or figure (P-5) by writing equation or figure that show the release and acceptance of electrons.

In the monitoring activity, metacognitive characteristic is using the rule (M-2) to predict the compound formula, it shows that subject using the knowledge that has been held to help

solve problems. Then subject monitoring something that is considered an error (M-3) proved with the erasures on the answer sheet.

Subject monitor closely in problem solving (M-4) by circle sign on Lewis symbol that shows the electrons in the atom that reach the stability and the arrow on the figure to indicate the release of electrons. Subject also monitoring by arguing (M-5) to explain the argument of the atom that release electrons and atom that accept electrons and connect it to the periodicity properties of the elements. This is suitable with North Central Regional Educational Laboratory (1995), stating that the activities which is done during the monitoring plan of action, are: how to do this, check whether it is on the right path, the way it should be continued, the information that is important to keep in mind, consideration of different ways, consideration in adjustment steps with regard to the difficulties [9].

Metacognitive characteristics of reflection activity is reflecting on the concept/ objectives have been achieved (R-1) to check the answers and believe the answers obtained, and reflecting the application/ use of more efficient strategies (R-2) by writing another way that can be used to solve problems. Activities that is done when evaluating the action, are: assessment of what has been done, thinking discourse special assessment will generate more or less than expected, check whether it can perform in a different way, the possibility of applying this method to other problem, whether to go back to initial task to fulfill part poor understanding [9]. High group showed activity planning, monitoring, and reflection that occupy level of reflective use.

2. Metacognitive Characteristic of Moderate Group

Problem solving is performed by the subject begins with thinking/ reading/ writing what is known and unknown (P-1) by writing a known compound and its atomic number, and define the problem-solving strategies (P-3) by writing the electron configuration to know valence electron. Metacognitive activity for the planning dimension in problem solving, such as thinking and writing what is known and what is unknown and identifying where to find information that is unknown [3]. Then the subject planning a representation in the form of figure to support understanding (P-5) by drawing the mechanism of release and acceptance of electrons.

Characteristics metacognitive in monitoring activity is monitoring something that is considered an error (M-3) in the presence of erasures on the answer sheet, and monitoring closely in problem solving (M-4) by the circle sign on Lewis symbol that shows electrons in atom that achieve stability. Sadiq (2013), revealed the importance of students knowing or realizing deficiency or excess of the ability to think so that students who have metacognitive knowledge will be able to control themselves to do or not do something [10]. The moderate group was only showing the metacognitive characteristics on planning and monitoring, and the subject does not perform reflection activity so it is placed at the level of strategic use.

3. Metacognitive Characteristic of Low Group

Problem solving is performed by the subject begins with thinking/ reading/ writing what is known and unknown (P-1) by writing a known compound and its atomic number, define problem-solving strategies (P-3) by writing the electron configuration to know valence electrons on each atom. Subject plans a representation of figure to support understanding (P-5) by drawing the mechanism of release and acceptance of electrons.

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Metacognitive characteristic in monitoring activity is monitoring closely in problem solving (M-4) by the circle signs on Lewis symbol that shows the electrons in the atoms that reach stability despite sometimes subject has confusion or difficulty of what is done. Flavell (1979), revealed that students need metacognitive so they can aware and connect the information that has been known to question of the problem so it can build a solution plan [4]. Low group only shows the metacognitive characteristics on planning and monitoring, and the subject does not perform reflection activity so it is placed at the level of aware use. Based on metacognitive characteristics above so it is obtained the finding in a pattern as follows:

Table 1 Student's Metacognitive Characteristic and its Level Pattern of High, Moderate, and Low Group

Student's Metacognitive Level	Student's Metacognitive Characteristic								
	Planning			Monitoring			Reflection		
	T	S	R	T	S	R	T	S	R
Tacit Use									
Aware Use			P-1 P-3 P-5			M-4			
Strategic Use		P-1 P-3 P-5			M-3 M-4				
Reflective Use	P-1 P-3 P-5			M-2 M-3 M-4 M-5			R-1 R-2		

Note:
T : High group
S : Moderate group
R : Low group
P-1 : Thinking/ reading/ writing what is known and unknown
P-3 : Defining problem solving strategies
P-5 : Planning an equation or picture representation to support understanding
M-2 : Using the rules
M-3 : Monitoring something that is considered an error
M-4 : Monitoring closely in problem solving
M-5 : Monitoring by arguing
R-1 : Reflecting the concept/ objectives have been achieved
R-2 : Reflecting the implementation/ use of a more efficient strategy

CONCLUSION

Based on result and discussion above, student's metacognitive characteristic and its level in problem solving of chemical bonding matter as follows.

1. Metacognitive characteristic in planning activity carried out by the students in high, moderate, or low group identified similar, but students in high group are better in planning a representation to support understanding.
2. Metacognitive characteristic in monitoring activity carried out by the students in high, moderate, or low group more varied. Students in high group doing more monitoring in problem solving.
3. Metacognitive characteristic in reflection activity is only done by students in high group, while students in moderate and low group did not perform reflection.
4. Students in high group placed in reflective use level, moderate group placed in strategic use level, and low group placed in aware use level.

SUGGESTION

Advice that can be given by researcher are:

1. Teacher should use learning model that can enhance students' metacognitive characteristics both on the activity of planning, monitoring, and reflection such as a model inductive learning, inquiry, and problem-based learning.

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2. Need to do more research related to the characteristics of metacognitive in solving problems of class X SMA to other materials because of the curriculum in 2013 metacognitive found on Main Competence 3 for class XI and XII SMA only.

REFERENCES

1. Kemendikbud. 2013. *Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia Nomor 69 Tahun 2013 tentang Kerangka Dasar dan Struktur Kurikulum Sekolah Menengah Atas/Madrasah Aliyah.* Jakarta: Kementerian Pendidikan dan Kebudayaan.

2. Uzuntiryaki, Esen and Geban, Omer. 2004. Effectiveness of Instruction Based on Constructivist Approach on Student's Understanding of Chemical Bonding Concepts. *Science Education International Vol. 15, No. 3, page 185-200.*

3. Pulmones, Richard. 2007. Learning Chemistry in a Metacognitive Environment. *The Asia Pacific-Education Researcher, Vol.16, No.2, page 165-183.*

4. Flavell, John. H. 1979. Metacognition and Cognitive Monitoring, A New Area of Cognitive-Developmental Inquiry. *American Psychologist. Vol.34, No.10, page 906-911*.

5. Polya, G. 1973. *How to Solve It. Second Edition*. New Jersey: Princeton University Press, Princeton.

6. Laurens, Theresia. 2009. *Penjenjangan Metakognitif Siswa*. Disertasi. Tidak Dipublikasikan. Surabaya: Universitas Negeri Surabaya.

7. Sugiarto, Bambang, dkk. 2012. Keterampilan Metakognitif Mahasiswa dalam Menerapkan Teori VSEPR pada Penyelesaian Masalah Bentuk Molekul dan Sudut Ikatan. *Jurnal Penelitian Pendidikan Matematika dan Sains, Vol.19, No.1, 14-25*. Universitas Negeri Surabaya.

8. Moleong, Lexy J. 2011. *Metodologi Penelitian Kualitatif*. Bandung: Remaja Rosdakarya.

9. NCREL. 1995. *Metacognition in Strategic Teaching and Reading Project Guidebook* (Online) http://www.ncrel.org/sdrs/areas/issues/students/learning/lr1metn.htm accessed on 6 March 2014.

10. Shadiq, Fajar. 2013. *Metakognisi: Apa dan Mengapa Penting?* (Online) http://p4tkmatematika.org/2013/12/metakognisi-apa-dan-mengapa-penting/ accessed on 12 March 2014.